

Using Companion Modelling to Understand Interactions between Water Dynamics and Labour Migrations in Lower Northeast Thailand

W. Naivinit¹, G. Trébuil²

¹ *Faculty of Agriculture, Ubon Ratchathani University, Ph.D. student at Chulalongkorn University, Thailand, and Paris X – Nanterre University, France*

² *CU – Cirad ComMod Project, Chulalongkorn University, Bangkok, Thailand*
wnaivinit@yahoo.com

Abstract

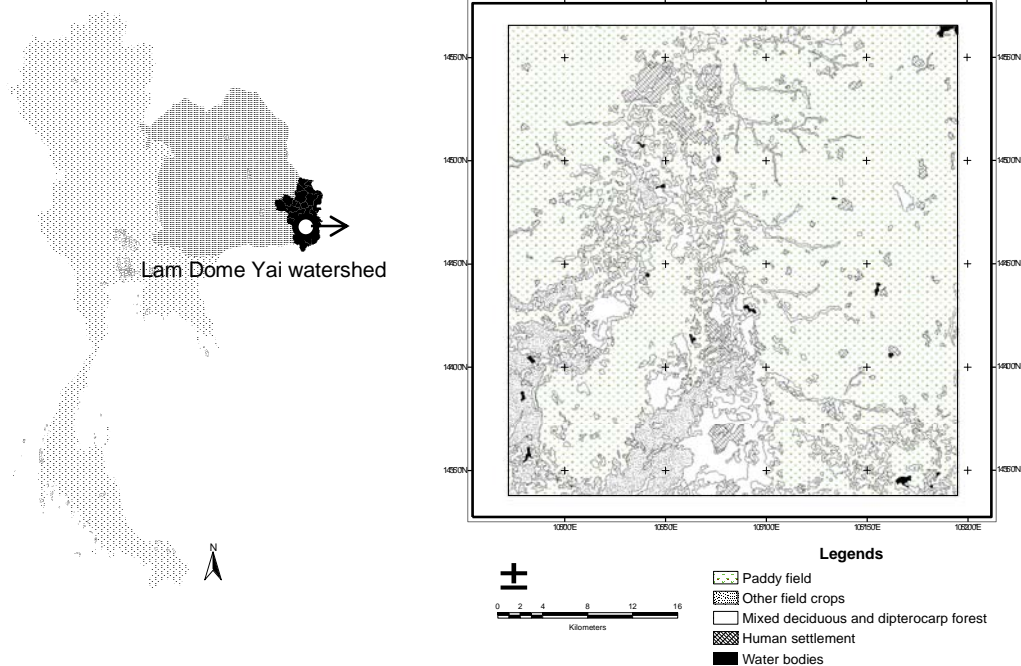
The human environment interaction influences the natural resource management. It needs to be clarified and understood by concerned stakeholders to ensure practical development. In lower northeast Thailand, the interaction between water dynamic of rainfed lowland rice ecosystem and labour migration plays a crucial role in shaping this agricultural community. Farmers' decision-making processes with regard to on-farm activities are generally determined by water and labour availability. The Royal Thai Government has been trying to alleviate the climatic risk by building small-scale water retentions but the impact is still limited. In this research, an innovative approach, Companion Modelling (ComMod), is used to build collective comprehension regarding such interaction via an associated key tools, Role-Playing Game (RPG) and Multi-Agent Systems (MAS) model with stakeholders throughout the research process. A comprehensive knowledge of interactions and representation of system components would help to design more adapted investments. Therefore, this research aims at understanding and modelling the interactions between water dynamics, land use, and labour migration. The hydrological model was built to represent the water balance, soil properties, and land-use types. Based on the initial conceptual model, rule-based social agents are implemented to represent the decision-making processes of heterogeneous stakeholders regarding farm and off-farm employment. The paper shows how a MAS model is used for collective discussion and scenario exploration with the stakeholders. The results of the game sessions and their use for improving the model are also presented. Finally the results of the simulation of a baseline scenario are discussed.

Introduction

“It is a gamble on the monsoon” a famous statement was posted by Lord Curzon in 1905. It was applied to agricultural practices under the vagaries of monsoon (Swaminathan 2005). This statement has been challenged to prove wrong for years. Sadly, his statement, even a century later, seems to hold good. Moreover, such the gamble becomes more complex because it causes various emergent phenomena and inventions rooted on our attempt to alleviate harsh environment interacting with our social and economic dynamics. For the decades, the pressure of rapid growth of population induces many environmental changes since we have to rival each other in order to achieve our own goal on the basis of limited natural resources. The outcome of our action is, in fact, influenced by interaction between ecological and socioeconomic dynamics. A key to win “the gamble” is to better understand how humans interact with each other and their natural environment. However, research on such interaction is complex, because of multiple scales of interaction and response; a high frequency of nonlinearity, uncertainty, and time lags; and diverse stakeholders (Costanza et al. 2002). An appropriate approach must be able to identify and implement decision-making processes, evolve as collective learning with stakeholders, develop tools that represent the real circumstance in scope of problem domain, encourage the shared representations of various stakeholders, and motivate behavioural changes. The aim of this communication is to present to you:

- State of the art of an innovative approach, Companion Modelling (ComMod) for knowledge integration and stakeholders' empowerment,
- Construction of Role-Playing Game (RPG) and a family of Multi-Agent Systems (MAS) models,

- Use of associated key tools, RPG and MAS model, in participatory way with local farmers to elicit mutual recognition regarding decision-making processes about the impact of water dynamic on cropping patterns and labour migration, and apply new knowledge to enrich the conceptual model and build a MAS model,
- Discussion on results of the simulation of a baseline scenario, and the revision of conceptual model.



Source: Department of Land Development 1991 adapted by Warong Naivinit

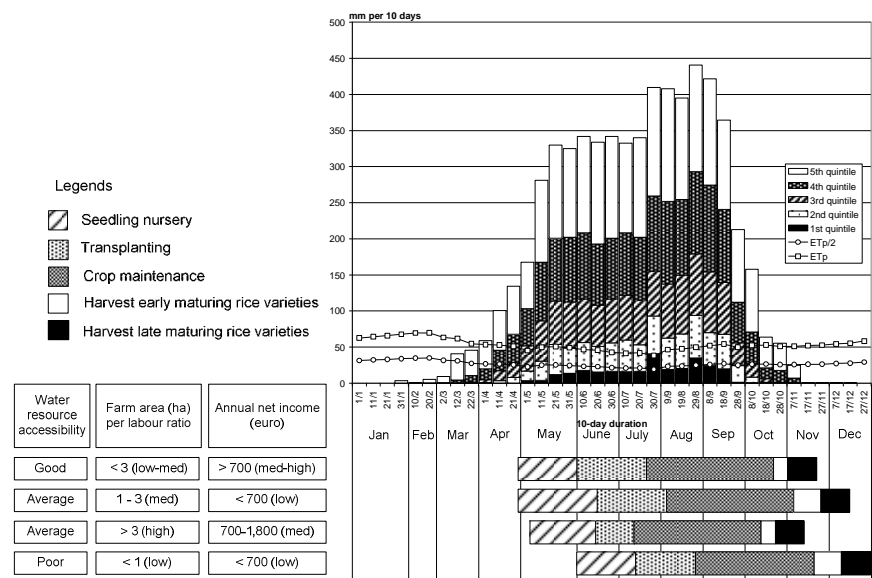
Figure 1: Location and land use types of the study area in Lam Dome Yai watershed, Ubon Ratchthani province, Thailand

Biophysical characteristics and socioeconomic dimensions

The Kingdom of Thailand is known as the “Golden Land”, in recognition of the high productivity of its farmlands and forests that benefit from the southeast monsoon. An evolution of this fertile country is based on the agricultural and technological development, by commerce and the slow infusion and mixing of diverse ethnics and cultures. The interplay between the cultural history, and technology and the country’s natural resources has shaped today’s Thailand, with all its economic potential and indubitable social and renewable resource problems. In the Northeast Thailand, these problems are more serious since 80% of farmland in this region is dominated by the highest water and labour demanded production, rainfed lowland rice (RLR). With the harsh environment especially water scarcity, the rice yield is very low about 1.8 t ha^{-1} (Somrith 1997). Even if the higher farm gate price rice variety “Jasmine aromatic rice” is largely produced in this region, it cannot compensate the low productivity that causes relatively low economic return. With regard to low household income of its people (252 US dollars per month), the region is known to be the poorest region in the country. According to 2002 census, the Northeast was the largest populated region, with 20.7 million inhabitants and a population density of 122.9 persons per km^2 . In the middle and late 1980s, a remarkable economic growth in Thailand made the urban-rural relationship more direct in term of people’s migration and circulation of information and money (Konchan et al. 1996). Comparing to other regions, the flow of labour in the Northeast Thailand is highest. The main season of migration is to search for higher profitable employment and the

career change from farmers to wage-earners. The wage has been increasingly dominated other sources of income that used to mainly rely upon the agricultural products.

The study area is located in the Lam Dome Yai, the largest watershed in Ubon Ratchathani province. This watershed supplies water to Mun River flowing eastward to join Mae Klong River at the Thai-Lao border. The study area is about 1,680 km² and major land use is agriculture. 80% of the agricultural area is dominated by rainfed lowland rice ecosystem while other crops and forest cover about 10% (Fig 1). This drought-prone area is characterized by course-textured and poor quality of soils, and erratic rainfall distribution. The dynamic of rainfall and different means of production such as farm ponds, household income, and farm-labour ratio influences decision-making processes of local farmers regarding their rice-cropping calendar (Fig 2) and migratory patterns.



Source: Daily rainfall and ETP data from Northeast Meteorological Center, Ubon Ratchathani

Figure 2: Effect of the variability of rainfall interacting with different means of production on rice-cropping calendar in rainfed lowland rice ecosystem, Lam Dome Yai watershed

Migration is considered a strategy to alleviate poverty, which is a result of the interaction between unfavourable agro-ecological conditions and the lack of local economic opportunity (Skeldon 2002). The migration rate is very high in this community causing farm labour at household level becomes inadequate. Due to inevitable flow of capitalism and the state agencies intervention to reduce climatic risks, the changes of traditional labour system (mutual help) and land/water utilization of local farmers are emerged to cope with household labour shortage. Hired labour has been a major source of farm labour replacing the family labour that migrates to cities. The diverging means of production including water accessibility invested by state agencies play an indispensable role in supporting the diversified cropping calendars, which are important for the existence of local labour market. In addition, a social problem regarding fragmented families is increasingly important to be taken into account as a result of migration.

Companion Modelling (ComMod) approach and methodology

The ComMod approach stems from adaptive management approach for collective ecosystem management. The approach aims to empower local stakeholders by increasing their adaptive capacity with regard to their renewable resources management (Bousquet et al. 2005). It also

aims at building a family of simulation models integrating various stakeholders' perceptions to develop a shared representation of the systems to be managed and of the problem to be examined, and to use them in an interactive process within the context of platforms for collective learning. The objective is to understand the interaction between ecological and socioeconomic dynamics and to support learning process leading to collective agreement.

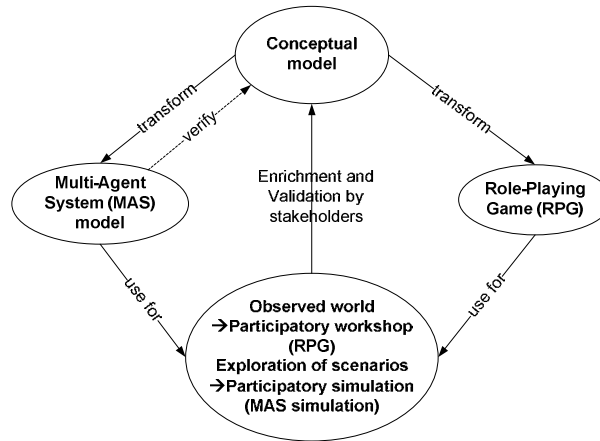


Figure 3: The companion modelling cycle

Two associated key tools, MAS model and RPG, are often used in a cyclic ComMod because of its similar implementation (Fig 3). The MAS model and RPG are built based on the same conceptual model constructed in Unified Modelling Language (UML) diagrams. The MAS model is based on the idea that it is possible to represent the behaviour of entities in computerized form, which are active in the world, and that it is possible to represent a phenomenon as the outcome of the interactions among an assembly of agents with their own operational autonomy (Ferber 1999). However the structure and rules of the RPG and MAS model is not completely the same because the RPG needs simpler to be organized and easier to be understood by the players.

Most of the ComMod projects deal with the complex situations in reality. Therefore, the important information regarding stakeholder decision-making processes, often embedded in mutual recognition, need to be acquired but the difficulty arises because the stakeholders need to be stimulated by interacting with real situation. The RPG seems appropriate to favour the involvement of the stakeholders to express their actions through the game designed to represent their real circumstance. At the same time, participants gain an idea of what the model is and they are then capable to following simulation and helping researchers to validate the MAS model (Bousquet 2002). The new knowledge from RPG is used to enrich the conceptual model and build a MAS model. The model, then, will be used in participatory simulations to facilitate the mediation process to derive and share common representation toward situation under study, and to enhance decision-making process by simulating alternatives scenario collectively suggested by stakeholders.

Materials and method

Knowledge synthesis and conceptual model formalization

A farm survey was carried out in the central part of the Lam Dome Yai watershed to identify the different main types of household-based agricultural production systems and to understand the determining factors of labour migrations among these different categories of farming households (Naivinit et al. 2004). The findings of this field survey integrating with interdisciplinary scientists' point of views were used to formalize the initial conceptual model as a series of class, activity, and sequence diagrams in the Unified Modelling Language (UML). These UML diagrams are an important base for model implementation. They

represent 1) structure and relationship of components in system under study (Fig. 4), and 2) farmers' decision-making processes regarding land, water, and labour management (Fig. 5).

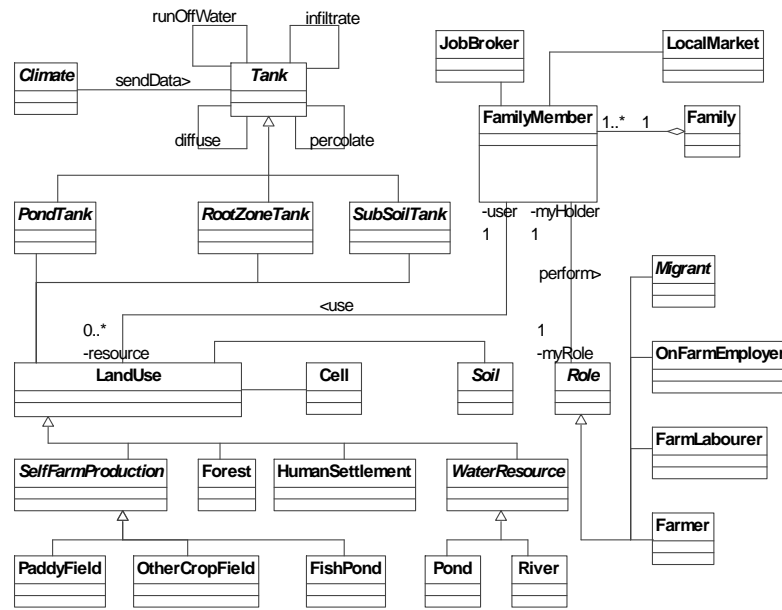


Figure 4: UML class diagram: Structure and relationship of components in system under study

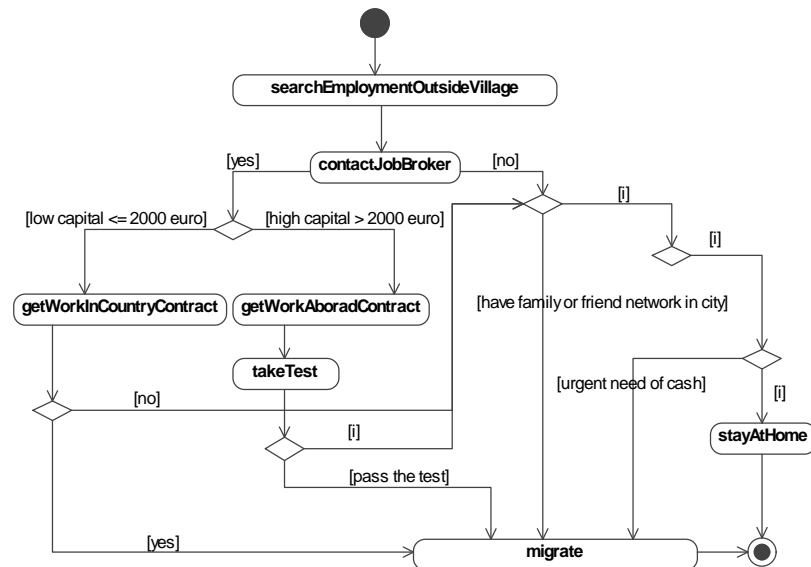


Figure 5: UML activity diagram: Farmers' decision-making process when the employment in village is not available

Construction of Role-Playing Games (RPG) and Multi-Agent Systems (MAS) model

Role-Playing Games (RPGs) were constructed to be used for participatory modelling workshops with concerned stakeholders. In this research, according to the objectives of RPG which focused on acquiring mutual recognition regarding rice production and labour migration of different farm types when dealing with different climatic situations and the water infrastructure improvement, some components such as forest, human settlement were not included. Generally, in this community, migration is considered as a collective decision-making process within a family. As a result, 11 households with two family members per a household were invited to join in the participatory workshops. All decisions were recorded and analyzed during individual interviews and plenary discussions after the game sessions to

clarify the players' decision-making processes and actions during the games. The results were used to enrich the initial conceptual model and then construct a MAS model.

Unlike RPG, the level of complexity of MAS model varies depending on the purpose of application. As a science-driven model, it characterizes more randomness and details dealing with scientific theories and stakeholders' perception for scientific explanation regarding the ecological and social processes. Nonetheless, it is more appropriate to implement a stakeholder-driven model regardless of randomness and scientific theories for knowledge sharing and facilitation of collective discussion. The science-driven MAS model consists of two integrated elements. The biophysical element was constructed to represent spatial data based on a GIS map (5 land use types, 12 soil series, and toposequence ranging from 120-210 meter). The prototype of hydrological processes was originally built at field level by a hydrologist (Lacombe et al. 2005). More variables regarding the spatial configuration and climatic variability were added to represent biophysical settings of the Lam Dome Yai watershed. The total simulated area is 1,680 km² with 0.16 km² cell-grid size (Fig. 6). The rule-based agents representing decision-makers (farmers) were implemented in this biophysical model as land/water users, and source of labour. As a result, the phenomenon regarding the change of land use and migratory patterns can be emerged from such virtual human-environment interaction. The model is built in CORMAS (Common-Pool Resources Multi-Agent System) platform, which is a programming environment dedicated to the creation of Multi-Agent systems, with a focus on the domain of natural resources management. CORMAS is being developed at CIRAD in Montpellier, France, and is based on the object-oriented language Smalltalk.

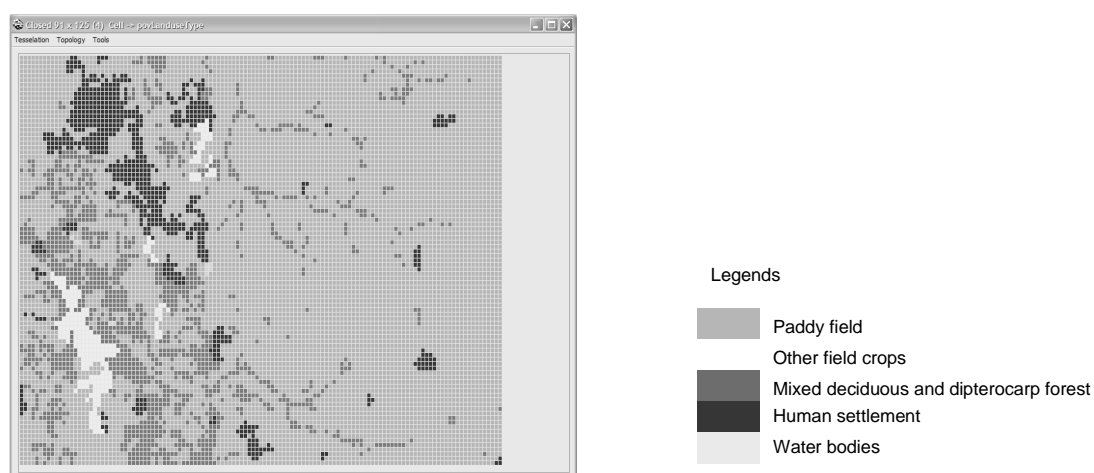


Figure 6: The spatial entities in MAS model

The science-driven MAS model was not tested during the participatory workshop because it was not simple enough to reflect the proposed RPG and could be difficult for players to understand and for moderators to explain at this stage of the process. The objective of using the MAS model during this workshop was to make the players be able to conceive the relationship between the RPG and the simulation and to facilitate the collective discussion among them. To serve such purpose, a stakeholder-driven MAS model based on the same conceptual model as the science-driven MAS model was implemented to represent exactly the same rules and sequence as the RPG.

Results and discussion

Use of associated key tools, RPG and MAS model

The result shows that communication among stakeholders was significantly improved during the presentation of the stakeholder-driven MAS model (compared to the RPG played the previous day). The follow-up interviews with individual participants elucidate the relationship

between the RPG and the MAS model that the RPG mainly helps the stakeholders to understand the rules and sequence of MAS simulation. Whereas the MAS model “playing the game” helps the stakeholders to better understand their situation. Without the RPG, it is not possible for stakeholders to understand the MAS simulations. Furthermore, all players agreed that the game represented their current situation regarding land/water use and labour migration.

The pattern of agricultural productions that closely interlink with labour migration is mainly determined by the distribution of rainfall. However, additional water resources such as farm ponds provide more flexible to farmers to start their rice production earlier so that the farmers can finish harvesting sooner and sell rice when its price is highest. For small holders, they generally do not have access to water resources and have to wait for the rain. Furthermore, it is necessary for them to be helped by returned migrant when producing rice. They become the important source of labour supply in the village. The migrants are considered as seasonal migrants who move to search off-farm employment when there is no local employment. For medium and large holders, the migratory pattern is more repeated migrants. The migrants do not return to help family during rice production but remit money to their families. Since the land-labour ratio for the medium and large holders is very high, they need to hire more labours during the utmost labour demand. The result of RPG shows that the diversity of farming systems mainly determined by water availability plays a major role in supporting local labour market because different farm types have different cropping calendar especially the calendar for rice production at the beginning of the rice cropping season. With this existing local labour market, the labour shortage at household level can be alleviated by hiring the neighbours whose paddy field is in waiting period.

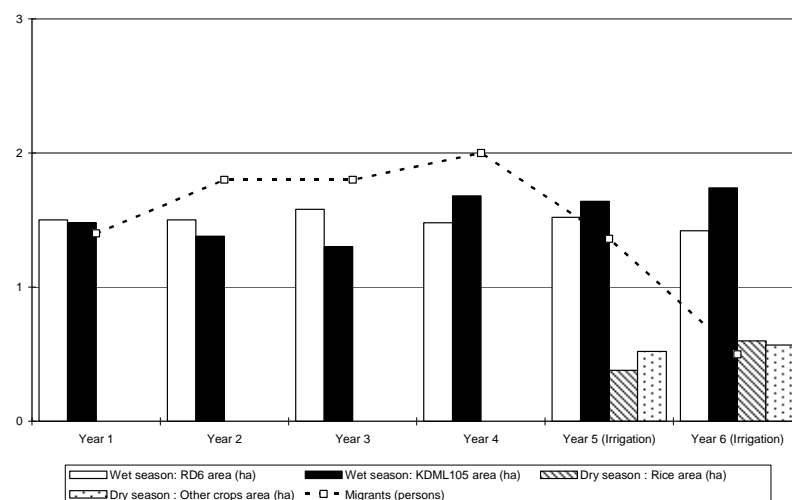


Figure 7: Average area of agricultural production and a number of migrants for small holders during the game played in participatory modelling workshop

A scenario of irrigation was introduced into the RPG. The result shows that small holders were more adaptive to take advantage of this water accessibility while it had little impact on medium and large holders. The small holders grew more cash crops in dry season and there were fewer migrants in this type of farm (Fig 7). The medium and large holders who normally rely on hired labour cannot plant dry-season crops because small holders who are the main source of labour supply are not available. This indicated that the improvement of water infrastructure only would not help all farmers to intensify their farm production because it could induce the labour scarcity which is also important to determine the capability of agricultural production in this community.

Results of the simulation of a baseline scenario and the revision of conceptual model

Follow-up individual interviews were carried out to clarify the decisions-making of players during the game sessions. The social processes regarding decision-making process on rice production and labour migration were validated. The conceptual model dealing with stakeholders' decision-making process at stage of land preparation for rice production was modified by adding new rules to rule-based agents; examine rice for family consumption of previous year and estimate need of rice for family consumption for current year in case of drought. The simulation of a baseline scenario was discussed among the players during the presentation of MAS simulation and baseline histograms in the participatory modelling workshop in April 2006. The result shows that an irrigated canal, which was introduced in the game, effectively provoked the farm intensification of small holders but not other types. However, the participants suggested that other types of water improvement such as individual farm ponds and artesian wells could be better solutions. These new knowledge regarding water improvement will be used to enrich the conceptual model and build a MAS model. The further discussion with stakeholders is needed to identify practical development in this community.

Conclusions and perspectives

Water availability is an important determinant for the farmers to decide whether to produce agricultural goods or migrate for off-farm employment. The erratic rainfall distribution and long dry season causing the poverty force this community to possess the high rate of migration leading to more fragmented families. Nevertheless, the alleviation of climatic risk such as an irrigated canal would not effectively motivate all farmers to intensify their farm production and change their migratory behaviours. In contrast, it would cause the labour shortage at community level to be more serious. The use of associated key tools, RPG and MAS model, in iterative way with high level of stakeholders' participation throughout the research process would help the farmers to build common understanding of the defined problems. Moreover, it is possible to use a MAS simulation for collective discussion among stakeholders. Thus, the MAS simulation based on the enriched conceptual model will be used with concerned stakeholders in series of participatory simulations for scenario exploration targeting at the collective agreement on desired development in this community.

Cited references

- Bousquet F. 2002. Multi-agent systems and role games: collective learning processes for ecosystem management, In: Complexity and ecosystem management: the theory and practice of multi-agent systems. Edward Elgar Publishing, Inc., Cheltenham, UK.
- Bousquet F, and Trebil G. 2005. Introduction to companion modeling and multi-agent systems for integrated natural resource management in Asia, p. 1-20, In: Bousquet F, Trebil G and Hardy B, eds. Companion Modeling and Multi-Agent Systems for Integrated Natural Resource Management in Asia. IRRI, Los Banos, the Philippines.
- Costanza R, and Jorgensen S. 2002. Understanding and solving environmental problems in the 21st century: towards a new, integrated hard problem science Elsevier, Oxford, UK.
- Ferber J. 1999. Multi-agent systems: an introduction to distributed artificial intelligence Addison-Wesley Longman Inc, New York.
- Konchan S, and Kono Y. 1996. Spread of direct seeding lowland rice in northeast Thailand: farmers' adaptation to economic growth. Southeast Asian Studies 33:5-28 p.
- Lacombe G, and Naivinit W. 2005. Modeling a biophysical environment to better understand the decision-making rules for water the use in the rainfed lowland rice ecosystem, p. 191-210, In: Trebil G, Bousquet F and Hardy B, eds. Companion Modeling and Multi-agent system for Integrated Natural Resource Management in Asia. IRRI, Los Banos, Philippines.
- Naivinit W, and Trebil G. 2004. Interactions between water use and labour migrations in northeast Thailand: Context, methodology, and preliminary findings. 4th International and Interdisciplinary Seminar of the Common Programme on Irrigated System (PCSI):

- Hydraulic Coordinations and Social Justice. Agropolis, Motpellier, France. 25-26 November 2004.
- NSO. 2002. Report of the 2002 household socioeconomic survey. National Statistical Office, Bangkok, Thailand
- Skeldon R. 2002. Migration and poverty. *Asia-Pacific Population Journal* 17:67-82.
- Somrith B. 1997. Cultivar improvement for rainfed lowland rice in Thailand. Breeding strategies for rainfed lowland rice in drought-prone environments, ACIAR Proceedings 77. Ubon Ratchathani, Thailand. 5-8 November 1996.
- Swaminathan M. 2005. Report of the task group on revamping and refocusing of national agricultural research. Government of India, Planning Commission (Agriculture Division), Yojana Bhawan, New Delhi.19.